III. *ECONOMICS AND ALLIED FIELDS*

THE RELATION OF ENGINEERING TO ECONOMICS

What is the value to an engineering student, a future engineer, of economics effectively taught? It will tend to broaden his views by showing engineering in its proper relation to other activities. It will help to develop the very valuable habit of thinking in terms of groups rather than of individuals, especially in matters of service. It will help the engineering student to see the real ultimate purposes of engineering. It will, for the best of engineering students, help to bring in the future years of engineering experience that wider vision which is the inspiration, the spiritual motive power of the great engineer.

Economics and engineering are closely related. Economics has been defined as the social science of earning a living. With the same appropriateness engineering may be defined to be physical science applied to helping groups of men to make a better living. That is but paraphrasing Tredgold's classic definition, "Engineering is the art of directing the great sources of power in nature for the use and convenience of man."

Two lines of thought so closely related as are economics and engineering necessarily react upon, and supplement, each other. Each line of thought aids in securing a complete understanding of the other. Four illustrations of the close relations between economics and engineering follow. The four illustrations deal with the effect of the development of the steam engine on economic conditions: the economic waste produced by poorly designed terminals and by the unnecessary use of terminals in large centers of population, the economic waste produced by sending freight over that one of two railways between two cities on which the actual cost of hauling the freight is the higher, and the advisability of neglecting some waterways.

It is immaterial for the present purpose whether you agree with my conclusions in these four illustrations. The important point is that in each of these illustrations, as in many other matters, true

conclusions are most likely to be reached by combining the closely related points of view of the engineer and the economist—that engineering and economics are so closely related that they react upon, and supplement each other. Hence effective teaching of economics will improve the future engineer.

Textbooks on economics find it necessary to a true understanding of that subject to state the great economic changes that were brought about by the development of the steam engine. The steam engine applied to driving machinery, and engineering achievement, brought about the factory system and other prominent features of our present industrial and commercial organization. Steam engines now enable coal to do ten times as much work each day as all of the men of the world could do in that day if they were all at hard physical labor. This immense increase in the available energy in the world, during the century of development of the steam engine, has produced great economic changes in the character of the work which is directly done by men and has immensely increased their total productivity.

The engineer endeavors to reduce the cost of transportation of freight from source to destination. Without the economist's point of view, he is apt to think of the source and destination on land as connected completely by the steel rails of a railway and to endeavor simply to reduce to the greatest possible extent the unit cost of hauling the freight over the road between terminals. If he takes the economist's habitual point of view he sees the source beyond one terminal and the destination beyond another. He sees that it is important, sometimes of paramount importance, to reduce terminal costs. He sees that the difficulties of keeping terminal costs down are much greater when the terminal is in the midst of a city of more than one million people than if it is not in a congested center of population. He sees that an economic waste, of which the ultimate consumer is the victim, occurs whenever goods are unnecessarily made to go to, or through, a terminal in New York or Chicago. Thinking in terms of economics serves in this case to concentrate the engineer's attention on one of the important points in his engineering problem, on the prime necessity of reducing or avoiding terminal costs in great cities.

A good railroad connects two large cities. An engineer with great care builds a second railroad between the same two cities which is shorter, with easier curves and lower grades, and on which the unit cost of hauling freight from city to city is considerably lower than on the first road. Then the rate makers induce about one-half of the freight to go over the line on which the actual cost of hauling is the higher. If that engineer also understands economics he sees that his work has been partly nullified by the rate makers, that it is an economic waste to the community as a whole to send one-half the freight by the more costly route. He is apt to be ready to insist, when he has the opportunity, that freight rates should be based, in part at least, on railway costs.

The decision as to what waterways should be developed for the good of the whole community, and which ones should be neglected, ought apparently to be made largely on an engineering basis. The engineer should—and can if he will apply his special knowledge wisely—reach nearly correct conclusions as to which waterways afford possibilities of reducing unit costs of hauling freight from source to destination to the minimum to which such costs can be reduced by railways alone. Yet many engineers, some of great ability, have certainly reached erroneous conclusions and have advocated canals, and improved rivers, on which the actual unit cost of freight haulage from source to destination cannot be made as low as it already is on railroads now in existence between said source and destination. A student of economics, the present secretary of the Western Economic Society, has written the best statement in existence on the problem of waterways *versus* railways. He has shown most clearly the fundamental fallacies of many waterways arguments—fallacies which engineers should have been first to see. This is a striking example of clear thinking in the economic field throwing a brilliant light on the engineering field.

Engineering is primarily service to the community, to large groups of men, rather than to individuals. Unfortunately many engineers fail to see this clearly. The study of economics should help to develop a social conscience in the student of engineering by forcing him to think in terms of groups of men.

It has been stated that economics effectively taught will help the engineering student to see the real ultimate purpose of engineering and help in furnishing inspiration in his later years.

An engineer deals largely with material things, but to achieve ultimate results that are not material in character. He locates and builds a railroad, a mere material thing. The railroad is to be used by running trains over it—mere material things again. But the most important ultimate purpose and effect of the railroad is to raise the standard of civilization of a region. By putting the region into closer contact with the remainder of the world, by making communication of intelligence more regular and easier, by facilitating movements of people, visits and migrations, it changes the habits of action and of thought of a people. By enlarging the market of the region it enables the population to utilize local advantages, to make their labor more productive. In a region far from all railroads and water transportation men may secure the bare necessities of life by hard labor. Within a network of railroads the typical man on eight to ten hours of work per day lives a relatively full life.

The inspiration of a great engineer has frequently come from a vision of the ultimate, not the material, results of his work. The great builder of irrigation projects saw not merely that the desert would yield great crops. He saw also the prosperous, steady, and reliable people that would there develop.

The great bridge engineer has seen with enthusiasm that removing barriers improves peoples by promoting co-operation in larger groups.

The great sanitary engineer, doing his part in improving the water supply of cities, sees back of coagulation tanks, sand filters, and protected watersheds not simply many lives saved, but also the general health of whole communities so improved that the standards of thought, of employment, of morals, are intangibly but certainly raised.

Note that in each of these cases the ultimate result of engineering is expressed in economic terms.

The inspiration makes the difference between the great engineer and the mere engineer.

Economics tends to lead the engineering student to the broader view that in turn gives the inspiration which produces the steady motive power that will drive the future engineer through discouragements and obstacles to achievements that are worth while.

Certain good effects upon engineering students have herein been indicated as resulting from effective teaching of economics. It should be noted that no suggestion is made that the content of the general course in economics or the manner of teaching it should be different for an engineering student than for other students either in liberal arts or specializing in economics. It is believed that to make such differences is a mistake which is to the disadvantage of the engineering student. Similarly, advanced courses in economics taken by engineering students should not differ either in content or manner of teaching from courses covering the same topics and offered to other students. The future engineer will profit most from the same broad thorough training in economics which is best for the other students just referred to. The writer has endeavored to set forth in this paper the reasons for this firm belief.

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